

1 IMAGE PROCESSING METHOD, RELATIVE DENSITY DETECTING METHOD
2 AND IMAGE PROCESSING APPARATUS

3 FIELD OF THE INVENTION

4 The present invention relates to an image processing
5 method and an apparatus thereof, which binarize a multi-
6 valued image having depth, more particularly to an image
7 processing method and an apparatus thereof, which exert per-
8 formance for cutting out characters and the like.

9 BACKGROUND OF THE INVENTION

10 Recent years, a digital camera and so on have been
11 developed, thus a request has been increased such that a
12 large number of images, each of which includes a large num-
13 ber of character images such as those on a white board used
14 at a conference and on a time table, should be taken into
15 photographs and stored, and later, character information and
16 the like should be read out from the photograph information.
17 Such a photograph image by a digital camera is a multi-
18 valued image having depth. If image information of the
19 multi-valued image is stored as it is and outputted accord-
20 ing to needs, it is possible to read out the character
21 information and the like from the photograph information of
22 the multi-valued image.

23 However, the multi-valued image has a large amount of
24 information, and storing the image information requires an
25 enormous amount of memories. For a request to simply read a
26 character, it is not preferable that the multi-valued image

is stored in memories as it is, and it is desirable that this multi-valued image is binarized to be stored in the memories. Such binarization of a multi-valued image having a depth is required for not only the foregoing example but also various other applications. For example, the binarization is required for the case where an image is reduced in size to be stored, the case of performing pre-processing made for recognizing an object in an image such as a character, the case of obtaining a special image processing effect (such as a woodcut print image) and so on. As principal binarization methods, there have conventionally existed a simple binarization method, an edge emphasis binarization method, a binarization method designed to pursue photograph quality as much as possible by using a binary printer driver program and so on.

Moreover, in a gazette of Japanese Patent Laid-Open No. Sho 63-108470, in consideration of a defect that the sphere of characters or figures whose binarized images may be sufficient is stored as multi-valued data, a technology is disclosed, in which information for classifying spheres into respective spheres to be saved as binary data and multi-valued data is added to image data and stored, thus the image data is stored in a small volume. Furthermore, in a gazette of Japanese Patent Laid-Open No. Hei 5-225388, a technology is disclosed, in which each pixel is filtered depending on a change of image densities of pixels existing on a periphery thereof to smoothen and thin image data, thus pre-processing is executed for enhancing clearness of an image to perform character recognition and so on.

However, the simple binarization method as described above is hardly used actually, though it is very simple.

1 For example, if in an image, there are dark and bright por-
2 tions that are mixed with each other, it often occurs that a
3 density of a character existing in the bright portion is
4 brighter than a background in the dark portion. For this
5 reason, with this simple binarization method, there remain
6 unsolved problems that an outline of a character or an
7 object in the bright portion or the like is faded and that
8 an outline of a character or an object in the dark portion
9 or the like turns solid black together with a background.
10 Moreover, the edge emphasis binary method cannot deal with a
11 character having, for example, a blurred outline, therefore
12 this method cannot be used for character recognition and the
13 like. Furthermore, the binarization method designed to pur-
14 sue photograph quality as much as possible by using a binary
15 printer driver program provides the most natural image
16 exhibiting good quality when viewed as a photograph by a
17 person, but this method is not suitable for character recog-
18 nition and cannot be used for the purpose of reducing a data
19 volume to a great extent. Furthermore, in the prior arts
20 described in the gazettes of Japanese Patent Laid-Open No.
21 Sho 63-108470 and Hei 5-225388, a calculation amount is
22 enormous and image processing to a great extent is required.
23 Accordingly, the image processing using the binarization
24 methods cannot be achieved with a simple system constitution
25 by these prior arts, and it is difficult to attain high-
26 speed processing therewith.

27 SUMMARY OF THE INVENTION

28 The present invention was made in order to solve the
29 forgoing technical subjects. An aspect of the present

1 invention is to provide an image processing apparatus, which
2 cut out, for example, a character and the like written with
3 a pen and so on, the character being relatively darker than
4 a background, at a high speed.

5 Another aspect of the present invention is to provide
6 an image processing apparatus and the like, which emphasize
7 an object without performing character recognition to com-
8 press an image size without damaging understandability of
9 the object.

10 It is still another aspect of the present invention to
11 obtain binary data, which has a small number of step differ-
12 ences and is smooth and high quality, even in the case where
13 a background density is referred in an attempt of high-speed
14 processing.

15 In order to achieve the foregoing aspects, according to
16 the present invention, an image processing system used for
17 pre-processing for cutting out a character and the like is
18 provided, in which attention is paid to that a character
19 written with a pen and so on is relatively darker than a
20 background, a relative density of such a character to a
21 periphery thereof is obtained and then the obtained relative
22 density is binarized, and thus an object such as a character
23 is emphasized and a background is brightened. Specifically,
24 an image processing method, to which the present invention
25 is applied, comprises the steps of: meshing an inputted
26 image into sub images, each of which has a specified size
27 and, for example, has a rectangular area to divide the
28 inputted image into pixel groups; calculating a pixel group
29 density for each of the divided pixel groups; and calculat-
30 ing an output value of a certain watched pixel based on an
31 absolute density of the watched pixel and a relative density

1 for the watched pixel, the relative density being calculated
2 based on the pixel group density of the pixel group, to
3 which the watched pixel belongs, and the pixel group density
4 of the pixel group adjacent to the pixel group, to which the
5 watched pixel belongs, among the pixel groups in the image.

6 BRIEF DESCRIPTION OF THE DRAWINGS

7 For a more complete understanding of the present inven-
8 tion and the advantages thereof, reference is now made to
9 the following description taken in conjunction with the
10 accompanying drawings.

11 Fig. 1 is an explanatory view showing an entire consti-
12 tution of an image processing apparatus according to this
13 embodiment.

14 Fig. 2 is a flowchart explaining a processing flow of
15 an image processing system according to this embodiment.

16 Fig. 3 is a view showing a constitution of a function
17 used in this system.

18 Figs. 4 (a) and 4 (b) are views respectively showing an
19 idea when obtaining a relative value and a trapezoidal func-
20 tion when obtaining a weight coefficient.

21 Figs. 5 (a) to 5 (d) are views showing image histograms
22 representing the functions used in this system shown in Fig.
23 3.

24 Figs. 6 (a) and 6 (b) are views showing examples of
25 image processing performed for images of time tables photo-
26 graphed by a digital camera.

27 Figs. 7 (a) and 7 (b) are views showing examples of
28 image processing performed for the images of the time tables
29 photographed by a digital camera.

1 Figs. 8 (a) and 8 (b) are views showing examples of
2 image processing performed for photographs of a dining table
3 taken by a digital camera.

4 Fig. 9 is a view showing an example of image processing
5 performed for the photograph of the dining table taken by a
6 digital camera.

7 DESCRIPTION OF THE INVENTION

8 Herein, "pixel group density" is a concept including
9 not only an average density of a pixel group described in
10 the embodiment but also a density of a typical pixel, for
11 example, a typical density in a pixel range having the larg-
12 est number of pixels. In this case, the typical density is
13 obtained by setting a specified number of density ranges and
14 obtaining a number of pixels entering each of the ranges.

15 Herein, the relative density may be calculated by use
16 of an influence degree calculated based on a distance from
17 the watched pixel and the pixel group, to which the watched
18 pixel belongs, to the pixel group adjacent to the pixel
19 group, each of the adjacent pixel group being located on and
20 under and at the right and left of the pixel group. Moreo-
21 ver, in the step of detecting the pixel group densities, an
22 average density of the divided pixel group may be
23 calculated, and the relative density may be calculated by
24 multiplying the respective average densities of the pixel
25 group, to which the watched pixel belongs, and of the pixel
26 group adjacent to the pixel group, to which the watched
27 pixel belongs, by the respective influence degrees. Fur-
28 thermore, the relative density may be calculated based on an
29 influence degree obtained by a trapezoidal function

T O S A C C O N F I D E N T I A L

1 representing a positional relation between a coordinate
2 position of the watched pixel and the pixel group adjacent
3 to the pixel group, to which the watched pixel belongs.
4 Conventionally, it has taken an enormous processing time to
5 calculate an average density of a periphery of a pixel, for
6 example, of the vicinity of $N \times N$, for each pixel in which a
7 relative density thereof is obtained. However, with the
8 above-described constitution, it is possible to execute
9 high-speed processing and to obtain an output image with a
10 quality hardly deteriorated.

11 Moreover, if the output value is calculated only with
12 the relative value, for example, it may sometimes occur that
13 values in both an entirely bright portion and an entirely
14 dark portion are equal to each other. In this case, an
15 image of a bright portion may be black, and an image of a
16 dark portion may be white. However, in the step of calcu-
17 lating this output value, the relative and absolute
18 densities may be weighted to calculate the output value,
19 thus it is possible to emphasize an object while maintaining
20 a feature of an original image.

21 On the other hand, according to the present invention,
22 a relative density detecting method for detecting a relative
23 density of a watched pixel constituting an inputted image
24 comprises the steps of: dividing the image into pixel
25 groups, each of which has a specified size; detecting a
26 pixel group density for each of the divided pixel groups;
27 extracting positional information for the watched pixel in a
28 pixel group including the watched pixel; and detecting a
29 relative density of the watched pixel based on the pixel
30 group density and the positional information.

1 Moreover, an absolute density of this watched pixel may
2 be detected, and a relative density may be detected, which
3 is obtained by adding a value obtained by multiplying a
4 pixel group density by a weight of positional information to
5 the detected absolute density. Thus, a step difference does
6 not occur in a portion in which a density varies smoothly,
7 and it is possible to represent a smooth density change in
8 the output image.

9 Furthermore, a weight of this positional information
10 may be calculated by applying a trapezoidal function repre-
11 senting a positional relation between a position coordinate
12 of the watched pixel and the pixel group adjacent thereto to
13 extract this positional information. In such a manner, sim-
14 plifying of the calculation is enabled, and this is
15 preferable in that a scale of image processing can be made
16 small and a processing speed can be accelerated.

17 Moreover, in order to achieve the foregoing aspects,
18 according to the present invention, an image processing
19 apparatus comprises: pixel group dividing means for dividing
20 an inputted image into pixel groups, each of which has a
21 specified size; pixel group density detecting means for
22 detecting a pixel group density for each of the pixel groups
23 divided by the pixel group dividing means; weight deciding
24 means for deciding each weight of the pixel groups adjacent
25 to the pixel, to which a watched pixel belongs, based on a
26 position of the watched pixel to be outputted; watched pixel
27 density detecting means for detecting a density of the
28 watched pixel; and relative density calculating means for
29 calculating a relative density of the watched pixel based on
30 a detected density of the watched pixel, a pixel group

1 density of the detected pixel group and a decided weight of
2 the pixel group.

3 Herein, the image processing apparatus may further com-
4 prise output density calculation means for calculating an
5 output density by performing predetermined weighting for the
6 density of the watched pixel detected by the watched pixel
7 density detecting means and the relative density calculated
8 by the relative density calculating means. With such a con-
9 stitution, for example, by properly executing weighting
10 based on the rule of thumb, emphasis of an object and out-
11 putting of a binarized image added properly with a feature
12 of the original image are enabled.

13 Moreover, this pixel group dividing means may roundly
14 divide an inputted image into meshes, each of which has I
15 pixels×J pixels (I, J: integers). With such a constitution,
16 this is preferable in that calculation for a background den-
17 sity can be executed at a high speed. Furthermore, this
18 weight deciding means may comprise a table look-up for
19 deciding weights of each pixel groups adjacent to a pixel
20 group, to which the watched pixel belongs, based on a coor-
21 dinate position of the watched pixel. In this case,
22 specifically, the pixel groups are located at the right and
23 left of the pixel group, to which the watched pixel belongs,
24 and/or on and under the pixel group, to which the watched
25 pixel belongs. Still further, this weight deciding means
26 may add weights of pixel groups located at the right and
27 left of the pixel group and adjacent to the same, to which
28 the watched pixel belongs, to obtain a sum of 1, and/or may
29 add weights of pixel groups located on and under the pixel
30 group and adjacent to the same, to which the watched pixel
31 belongs, to obtain a sum of 1. With the above-described

constitution, a simple function can be applied to the meshes located on and under and at the right and left of the pixel group, to which the watched pixel belongs, that is, adjacent thereto. Thus, it is possible to obtain a smooth and high-quality binarized image.

Furthermore, according to the present invention, an image processing apparatus for converting image data, which includes a specified object photographed by a digital camera, into a binarized image, may comprise: a meshing unit for meshing the entire image data into sub images; an average density detection unit for detecting an average density of each of the sub images meshed by the meshing unit; and a density detection unit for detecting a density of a pixel constituting the object. In this case, a binarized image, in which an outline of the object is emphasized, may be generated based on a detected density of the pixel, an average density of the sub image, to which the pixel belongs, and an average density of the sub image adjacent to the certain sub image. With such a constitution, it is possible to obtain a high-quality binarized image at a high speed, and even in the case of compressing an image size, it is possible to obtain a binarized image, which can bear comparison with the multi-valued image in readability of an object such as a character.

DETAILED DESCRIPTION OF THE ADVANTAGEOUS EMBODIMENT

An embodiment of the present invention will be described in detail with reference to the accompanying drawings below.

Fig. 1 is an explanatory view showing an entire constitution of the image processing apparatus according to this embodiment. This image processing apparatus can be constituted as software, for example, in a personal computer, or can be constituted as hardware or software, for example, in a digital camera. Moreover, this image processing apparatus can be applied as an apparatus of cutting out a character as pre-processing for a character recognition apparatus. A reference numeral 11 denotes an image data input unit for inputting color image data of R (red), G (green) and B (blue), and a numeral 12 denotes a gray conversion unit for converting color image data inputted from the image data input unit 11 into multi-valued gray image data. Image data inputted to this image data input unit 11 is, for example, image data read out from an optical image reading apparatus such as a picked-up image data with a digital camera, and image data read out from a scanner, which is equipped with a line sensor in a main scanning direction and scans an image in a sub scanning direction to read an image. In this gray conversion unit 12, the existing gray conversion system can be employed, in which, for example, each image data of R, G and B is subjected to gray conversion and the converted image data are added to convert the same into gray image data having 256 gray scales from 0 to 255 gray scales. Moreover, the image processing may be individually performed for each of color signals R, G and B to calculate output densities thereof, thus adding the converted image data finally. Furthermore, in the case where the gray image data rather than the color image data is inputted, the gray conversion unit 12 may be omitted, and the image processing may be performed based on this gray image data.

1 A reference numeral 13 denotes a meshing unit for mesh-
 2 ing the gray image data (M pixels×N pixels) converted by the
 3 gray conversion unit 12 to sub images, each of which has I
 4 pixels×J pixels, for example, 10 pixels×10 pixels. A
 5 numeral 14 denotes an average density detection unit for
 6 obtaining an average density in each of the meshes (sub
 7 images) meshed by the meshing unit 13. A numeral 15 denotes
 8 an average density storage unit for respectively storing the
 9 average densities obtained by the average density detection
 10 unit 14. A numeral 16 is a watched pixel position detection
 11 unit for detecting that a watched pixel exists in a mesh
 12 located in an i-th column and an j-th row, for example, from
 13 a fact that the watched pixel is a pixel in m-th column and
 14 n-th row, or contents meshed by the meshing unit 13 and the
 15 like. A numeral 17 denotes an absolute density storage unit
 16 for storing a density (absolute density) of each of the pix-
 17 els including the watched pixel.

18 A reference numeral 18 denotes a watched pixel weight
 19 coefficient storage unit for storing an influence degree
 20 (relative relation) for meshes located on and under and at
 21 the right and at the left of the watched pixel and at as a
 22 weight coefficient. For example, if the meshed sub image is
 23 constituted of 10 pixels×10 pixels, the weight coefficient
 24 is stored in a table of the watched pixel weight coefficient
 25 storage unit 18 as, for example, ten coefficients, that is,
 26 0.05, 0.15... 0.85, 0.95. A numeral 19 denotes a relative
 27 density calculation unit for calculating a relative density
 28 for each watched pixel in consideration of brightness in the
 29 periphery of the watched pixel based on each of the data
 30 from the average density storage unit 15 and the absolute
 31 density storage unit 17 and a weight coefficient read out

1 from the watched pixel weight coefficient storage unit 18.
 2 A numeral 20 denotes a weight coefficient storage unit for
 3 storing weight values of the relative and absolute densities
 4 such as a value based on the rule of thumb, for example,
 5 that a weight of the absolute value is reduced to
 6 one-eighth. A numeral 21 denotes an output density calcula-
 7 tion unit for calculating an output density from the
 8 relative density calculated by the relative density calcula-
 9 tion unit 19 based on a weight obtained by the weight
 10 coefficient storage unit 20 and the absolute density of the
 11 watched pixel read out from the absolute density storage
 12 unit 17. A numeral 22 denotes an image data output unit for
 13 outputting an image having a final density calculated by the
 14 output density calculation unit 21 to a next step thereof
 15 such as a memory and printing devices.

16 Fig. 2 is a flowchart explaining a processing flow of
 17 the image processing system according to this embodiment.
 18 First, from a result of the gray conversion unit 12 and the
 19 like, a gray image having M pixels×N pixels is obtained
 20 (step 101). This obtained gray image is meshed into sub
 21 images having, for example, 10 pixels×10 pixels, to form I×J
 22 meshes (pixel group) (step 102). Next, an average density
 23 in each of the meshes is obtained. (step 103). For example,
 24 if the gray image is meshed into 10 pixels×10 pixels, an
 25 average value (density) of 100 pixels (=10 pixels×10 pixels)
 26 is calculated. Then, an absolute density of each watched
 27 pixel is obtained (step 104), and by using this absolute
 28 density, a relative density to five meshes (mesh including
 29 watched pixel itself, two meshes on and under the center
 30 mesh and two meshes at the right and left of the center
 31 mesh) is obtained for each watched pixel (step 105).

1 Thereafter, a final density is decided by a function added
2 with the absolute and relative densities for each watched
3 pixel (step 106).

4 Next, description will be made in detail for a function
5 used in this system.

6 Fig. 3 shows a constitution of the function used in
7 this system. $[P]_{mn}$ shows a final value (density) of a pixel
8 located in the m -th column and the n -th row. This final
9 value is schematically calculated from a value added with a
10 constant C , a value added with the absolute value and a
11 value added with the relative value. Specifically, in an
12 equation shown in Fig. 3, a first term of a right side
13 thereof represents a constant term, a second term thereof
14 represents the one obtained by multiplying the absolute
15 value by α , and a third term thereof represents the one
16 obtained by multiplying the relative value by β . This third
17 term of the right side is added with a relative value given
18 in consideration of a mesh itself (in an i -th column and a
19 j -th row) and meshes on and under the mesh and a relative
20 value given in consideration of the mesh itself and two
21 meshes at the right and left sides. Herein, if the final
22 value is decided only with the relative values, for example,
23 it may sometimes occur that values in both an entirely
24 bright portion and an entirely dark portion are equal to
25 each other. Thus, there exists a possibility of a result
26 which is occurred to be a different image from an actual
27 image. For example, an image of a bright portion may be
28 black, and an image of a dark portion may be white. For
29 this reason, this system is constituted such that the final
30 value can be decided by adding the absolute value.
31 Moreover, the absolute value P_{mn} of the watched pixel is

1 multiplied by the weight coefficient α . In this case, exper-
 2 rientially, the value α is preferably reduced to about
 3 one-eighth. Furthermore, the final value may sometimes fall
 4 in a minus if the absolute value is made small when the
 5 final value is calculated with the relative value. There-
 6 fore, as the constant C, a value, which is decided
 7 experientially so that the final value is not to fall in a
 8 minus, is employed. Note that in this function, an average
 9 density of a mesh image in the i -th column and the j -th row,
 10 to which the watched pixel belongs, is represented as $S_{i,j}$, an
 11 average density of a mesh image located thereon is repre-
 12 sented as $S_{i-1,j}$, an average density of a mesh image located
 13 thereunder is represented as $S_{i+1,j}$, an average density of a
 14 mesh image located at the left thereof is represented as
 15 $S_{i,j-1}$, and an average density of a mesh image located at the
 16 right thereof is represented as $S_{i,j+1}$. Furthermore, a weight
 17 coefficient of the mesh on the watched pixel is represented
 18 as d_1 , a weight coefficient of the mesh at the left thereof
 19 is represented as d_2 , a weight coefficient of the mesh at the
 20 right thereof is represented as d_3 , and a weight coefficient
 21 of the mesh thereunder is represented as d_4 .

22 In this function shown in Fig. 3, for example, parame-
 23 ters may be designated as follows:

24 In the original image: $C=0$, $\alpha=1$, $\beta=0$;

25 in the image only having the relative value:

26 $C=\text{plus value}$, $\alpha=0$, $\beta=\text{plus value}$; and

27 in the image added with the absolute value and the
 28 relative value:

29 $C=\text{plus value}$, $\alpha=\text{plus value}$, $\beta=\text{plus value}$.

1 With the above designation of the parameters, various
2 images including an image enlarged in contrast can be formed
3 at a high speed.

4 Figs. 4 (a) and 4 (b) are views respectively showing an
5 idea when obtaining the relative value and a trapezoidal
6 function when obtaining the weight coefficient. In Fig. 4
7 (a), as explained with reference to Fig. 3, an average den-
8 sity of a mesh image in the i -th column and the j -th row, to
9 which the watched pixel belongs, is represented as $S_{i,j}$, an
10 average density of a mesh image located thereon is repre-
11 sented as $S_{i-1,j}$, an average density of a mesh image located
12 thereunder is represented as $S_{i+1,j}$, an average density of a
13 mesh image located at the left thereof is represented as
14 $S_{i,j-1}$, and an average density of a mesh image located at the
15 right thereof is represented as $S_{i,j+1}$. In this example, the
16 watched pixel is located at the upper right position in the
17 mesh image in the i -th column and the j -th row. The influ-
18 ence degrees (weights) received from the mesh images by the
19 watched pixel are as follows. The weight is 1 in the mesh
20 in the i -th column and the j -th row. Since the watched
21 pixel is located close to the mesh located on the mesh, to
22 which the watched pixel belongs, the weight d_1 is equal to
23 0.85 in the mesh in the i -th column and the j -th row. The
24 weight d_4 is equal to 0.15 in the mesh thereunder. The
25 weight d_2 is equal to 0.35 in the mesh at the left thereof.
26 The weight d_3 is equal to 0.65 in the mesh at the right
27 thereof. Herein, $d_1+d_4=1$ and $d_2+d_3=1$, and the mesh has 10
28 pixels \times 10 pixels. Therefore, in consideration of the cen-
29 ters of the respective pixels, the respective weight values
30 can take ten values as described above, that is, 0.05,
31 0.15,...0.85 and 0.95.

The relation of the weight coefficients when obtaining the relative value can be easily explained with reference to the trapezoidal function shown in Fig. 4 (b). In Fig. 4 (b), an example of obtaining the weights of the mesh images located at the right and left of the mesh, to which the watched pixel belongs, by use of the positional relation in the X-coordinate is illustrated. The upper side of this trapezoidal function shows a position of the sub area (mesh image) in the i-th column and the j-th row in which the watched pixel exists, and a length thereof is 1. The hypotenuses slant from both ends of the upper side downward to the right and left directions have a slant, which has a width of 1 and a height of 1.

Now, the X-coordinate of the watched pixel is assumed as nc , the X-coordinate of the left end of the watched pixel in the mesh is assumed as nl (X-coordinate of the pixel at the left end in the mesh-0.5), and the size of the mesh image is assumed as Sz . In this case, for example, the weight coefficient d_2 of the mesh at the left of the mesh in the i-th column and the j-th row and the weight coefficient d_3 of the mesh at the right of the mesh in the i-th column and the j-th row can be obtained in the following equations.

$$d_2 = 1 - (nc - nl) / Sz$$

$$d_3 = (nc - nl) / Sz$$

Results obtained from the above equations can be also obtained from the trapezoidal function shown in Fig. 4 (b), that is, d_2 can be obtained from the left hypotenuse and d_3 can be obtained from the right hypotenuse. Note that, similarly to the above, the weight coefficients d_1 and d_4 of the mesh images on and under the center mesh can be obtained from the positional relation of the Y-coordinate.

1 In the foregoing manner, the weight coefficients are
2 previously calculated in this embodiment, and can be easily
3 obtained by a table look-up while calculating $[P]_{mn}$. By
4 obtaining the weight coefficients with the above-described
5 system, background values as bases for comparison among the
6 respective pixels at the positions in the meshes can be made
7 to differ delicately from one to another, thus it is possi-
8 ble to obtain a smooth image without suddenly bringing about
9 a great change of the image at a boundary of the meshes.

10 Note that although the average density of the four mesh
11 images located on and under and at the right and left of the
12 mesh in the i -th column and the j -th row is used as the
13 relative density of the meshes adjacent to each other, the
14 average density of the slant images may be further added as
15 long as the processing is permitted to fall a little compli-
16 cated.

17 Figs. 5 (a) to 5 (d) are views showing image histograms
18 representing the functions used in this system shown in Fig.
19 3. Fig. 5 (a) shows an original histogram. Fig. 5 (b)
20 shows a histogram where the absolute value in the original
21 histogram of Fig. 5 (a) is multiplied by a (herein, by $1/8$).
22 Fig. 5 (c) is a histogram where the relative value obtained
23 by the algorithm as described above is added to the histo-
24 gram of Fig. 5 (b). Under the condition that the relative
25 value is simply added, the histogram may include a minus
26 value in some cases. Therefore, in this embodiment, the
27 constant C is added as shown in Fig. 5 (d) to jack up the
28 histogram, thus adjusting an output value.

29 Next, description will be further made for this embodi-
30 ment with reference to output examples.

1 Figs. 6 (a) and 6 (b) and Figs. 7 (a) and 7 (b) show
2 examples of image processing performed for images of time
3 tables photographed by a digital camera. Note that in these
4 views, there appear images, which are against the present
5 applicant's will due to conversion at the time of filing the
6 present invention. Herein, the parameters of the function
7 shown in Fig. 3 are set as follows.

8 constant $C=64$, $\alpha=1/8$, $\beta=1$

9 And the mesh size is set as $Sz=8$. Fig. 6 (a) shows an image
10 obtained by printing an 8-bit multi-valued image so as to
11 have high image quality as possible by a printer driver.
12 From this image, it is possible to read time data such as a
13 character 51 and the like. However, a data volume thereof
14 is 51.5kB (tif file compressed with JPEG), which is consid-
15 erably large. Fig. 6 (b) shows an image obtained by
16 subjecting the original image to the conventional simple
17 binarization. In this case, a data volume thereof is
18 reduced to 5.0kB (tif file compressed with G4MMR), which is
19 small. However, in this case, there are many characters,
20 which can not be read. For example, it is difficult to
21 determine the character 51. Moreover, a background 52 also
22 appears differently from an actual image thereof to a great
23 extent. On the other hand, Fig. 7 (a) shows a binarized
24 image obtained by performing relative value calculation
25 thereto not by use of the above-described trapezoidal func-
26 tion but by use only of the mesh, to which the watched pixel
27 belongs. In this case, a data volume thereof is 7.7kB
28 (G4MMR), which is small, and it is possible to read the
29 character 51 precisely. Moreover, a background 52 expresses
30 a feature of an actual image thereof. However, the back-
31 ground 52 is affected by the influence of the boundary of

1 the meshes, hence there are some places where unnatural rug-
2 gedness occurs. Fig. 7 (b) shows a binarized image obtained
3 by further performing relative value calculation by use of
4 slope functions of the trapezoids located on and under and
5 at the right and left of the certain mesh. Herein, a data
6 volume thereof is 9.7kB (G4MMR), which is small. Moreover,
7 ruggedness on the background 52 disappears, hence a consid-
8 erably natural binarized image is achieved. Furthermore, it
9 is possible to determine the character 51 sufficiently.
10 Accordingly, obtained readability of the character 51 can
11 even bear comparison with the multi-valued image shown in
12 Fig. 6 (a).

13 Figs. 8 (a) and 8 (b) and Fig. 9 are views showing
14 examples of image processing performed for photographs of a
15 dining table taken by a digital camera. Note that, also in
16 these views, there appear images, which are against the pre-
17 sent applicant's will due to conversion at the time of
18 filing the present invention. Fig. 8 (a) is a binarized
19 image obtained by processing the taken image into 8-bit
20 multi-valued image and then subjecting the 8-bit multi-
21 valued image to an error diffusion method as a prior art.
22 In this case, an image size thereof is 62.0kB (G4MMR), which
23 is large. Fig. 8 (b) shows an image obtained by subjecting
24 the image of Fig. 8 (a) to the simple binarization. In this
25 case, an image size thereof is 5.7kB (G4MMR), which is
26 small. However, the image is greatly defaced, and it is
27 hardly possible to determine an outline thereof. On the
28 other hand, Fig. 9 shows an image subjected to image proc-
29 essing with the system according to this embodiment. In
30 this case, an image size thereof is 15.0kB (G4MMR), which is
31 relatively small. Moreover, it is possible to clearly

1 express existence of objects. Accordingly, an artistic
2 image can be obtained, and it is possible to utilize the
3 image as a rough copy for a woodcut print.

4 As described above, with the image processing method
5 according to this embodiment, image processing is performed
6 by properly combining the absolute value and the relative
7 value, thus the image processing method can be used for
8 various purposes such as pre-processing for cutting out an
9 object including a character, storing memo data on a white
10 board, a time table of a bus service and the like, making a
11 rough copy for a woodcut print. With the image processing
12 method, extraction of a character can be achieved with a
13 high quality. Accordingly, it is possible to apply the
14 image processing method, for example, to pre-processing for
15 an automatic reading system of postal matters' addresses.
16 Moreover, with this image processing method, it is possible
17 to reduce an image size to about 1/5 compared with that of
18 the 8-bit multi-valued image. Accordingly, a great effect
19 can be obtained, for example, in the case where a large
20 amount of images photographed by a digital camera are
21 desired to be stored. Furthermore, since the image process-
22 ing method is realized by use of a simple function, the
23 image processing can be carried out at a high speed, and
24 nevertheless, a binarized image having a high quality can be
25 obtained.

26 Moreover, there may be provided a user interface for
27 allowing the equation shown in Fig. 3 to change. Thus,
28 adjustment can be performed so as to correspond to a charac-
29 teristic of an image to be processed, for example, an image
30 having overall a small (or large) contrast, an image having
31 a character or an object desired to be determined, which has

1 an outline and the like close to (or sufficiently different
2 from) a background thereof in density, and an image where
3 black dots such as noises appeared on the surface of an
4 object are apt to appear, the noise being occurred by an
5 influence of the object or the background and not being
6 desired by a user. Moreover, adjustment can be performed
7 reflecting an effect intended by a user.

8 For example, the equation of Fig. 3 is assumed to be
9 further converted as follows.

$$[P]_{mn} = C + (\alpha + \beta) P_{mn} - \beta (nS_{1j} + d_1 S_{1-1j} + d_4 S_{i+1j} \\ + d_2 S_{1j-1} + d_3 S_{i+1j}) / (n+2)$$

12 First, by changing the value C, brightness (density) of the
13 overall image can be changed. Moreover, by changing the
14 value α to a sufficiently larger value in comparison with
15 the value β , an image closer to the simply binarized images
16 shown in Fig. 6 (b) and Fig. 8 (b) can also be obtained.
17 Then, by changing the value n, the influence given to the
18 relative value between the mesh including the watched pixel
19 and the meshes adjacent thereto can be changed.

22 Furthermore, by reducing the mesh itself in size, the
21 image is apt to be affected by the influence of the density
22 change of the fine portions thereof. Accordingly, the image
23 made to reflect the patterns and the like of the fine por-
24 tions generated depending on a material of the object can be
25 obtained.

26 Moreover, in the advantageous embodiment of the present
27 invention, the influence degree of the meshes adjacent to
28 each other has been described with reference to the linear
29 function inversely proportional to the distance of the adja-
30 cent meshes and the watched pixel. However, the influence
31 degree can be calculated with reference to other functions

1 such as the multidimensional function and the trigonometric
2 function.

3 As described above, according to the present invention,
4 it is possible to cut out a character and the like at a high
5 speed, which are written with a pen and so on the character
6 being relatively darker than a background in a multi-valued
7 image, to use the cutting-out of a character for pre-
8 processing for character recognition and the like, to
9 emphasize an object such as a character and a figure, and to
10 compress an image size without damaging understandability of
11 the object.

12 The present invention can be realized in hardware, soft-
13 ware, or a combination of hardware and software. The present
14 invention can be realized in a centralized fashion in one
15 computer system, or in a distributed fashion where different
16 elements are spread across several interconnected computer
17 systems. Any kind of computer system - or other apparatus
18 adapted for carrying out the methods described herein - is
19 suitable. A typical combination of hardware and software
20 could be a general purpose computer system with a computer
21 program that, when being loaded and executed, controls the
22 computer system such that it carries out the methods
23 described herein. The present invention can also be embedded
24 in a computer program product, which comprises all the fea-
25 tures enabling the implementation of the methods described
26 herein, and which - when loaded in a computer system - is
27 able to carry out these methods.

28 Computer program means or computer program in the pre-
29 sent context mean any expression, in any language, code or
30 notation, of a set of instructions intended to cause a system
31 having an information processing capability to perform a

1 particular function either directly or after conversion to
2 another language, code or notation and/or reproduction in a
3 different material form.

4 It is noted that the foregoing has outlined some of the
5 more pertinent objects and embodiments of the present inven-
6 tion. This invention may be used for many applications.
7 Thus, although the description is made for particular
8 arrangements and methods, the intent and concept of the
9 invention is suitable and applicable to other arrangements
10 and applications. It will be clear to those skilled in the
11 art that other modifications to the disclosed embodiments can
12 be effected without departing from the spirit and scope of
13 the invention. The described embodiments ought to be con-
14 strued to be merely illustrative of some of the more
15 prominent features and applications of the invention. Other
16 beneficial results can be realized by applying the disclosed
17 invention in a different manner or modifying the invention in
18 ways known to those familiar with the art.

19 Thus, although the advantageous embodiments of the pre-
20 sent invention have been described in detail, it should be
21 understood that various changes, substitutions and alterna-
22 tions can be made therein without departing from spirit and
23 scope of the invention as defined by the appended claims.